

Amendments

Please amend the claims as follows:

1 1. (currently amended) A method for controlling the rate for  
2 encoding a video sequence, wherein the video sequence comprises a  
3 plurality of Group Of Pictures, wherein each Group of Picture  
4 comprises at least an I-frame and an Inter-frame, the method  
5 comprising the following ~~steps~~ for the encoding of each Inter-  
6 frame in the Group of Picture:

7       ·Determining a desired frame rate based on an available  
8 bandwidth of a channel which is used for transmitting the  
9 video sequence and on available computational resources for  
10 the encoding process;

11       ·Determining a target buffer level based on the desired  
12 frame rate and the position of the Inter-frame with respect  
13 to the I-frame; and

14       ·Determining a target bit rate based on the target  
15 buffer level and the available channel bandwidth, wherein the  
16 target bit rate is used for controlling the rate for encoding  
17 the video sequence.

1 2. (currently amended) The method for rate control according  
2 to claim 1, further comprising ~~the further steps of~~:

3       Determining a target encoding time interval for the  
4 Inter-frame; and

5       Determining the desired frame rate based on the  
6 determined target encoding time interval.

1 3. (Original)       The method for rate control according to  
2 claim 2, wherein the target encoding time interval for the  
3 Inter-frame is determined based on the available channel  
4 bandwidth and an average encoding time interval used for  
5 encoding the Inter-frame, wherein the average encoding time  
6 interval for the Inter-frame is proportional to the available  
7 computational resources for the encoding process.

1 4. (Original) The method for rate control according to  
 2 claim 3, wherein the target encoding time interval for the  
 3 Inter-frame is determined using the following equations:

$$\begin{aligned}
 5 \quad T_{fi}(n) &= A_1 * T_{fi}(n-1) & \text{if } B_{mad}(n) > B_1 * TB_{mad}(n), \\
 6 \quad T_{fi}(n) &= A_2 * T_{fi}(n-1) & \text{if } B_{mad}(n) < B_2 * TB_{mad}(n), \\
 7 \quad T_{fi}(n) &= T_{fi}(n-1) & \text{otherwise,}
 \end{aligned}$$

8  
 9 wherein

10  $T_{fi}(n)$  is the target encoding time interval for the Inter-  
 11 frame,

12  $A_1$  is a parameter wherein  $0.80 < A_1 < 1.00$ ,

13  $A_2$  is a parameter wherein  $1.00 < A_2 < 1.10$ ,

14  $B_1$  is a parameter wherein  $1.00 < B_1 < 2.00$ ,

15  $B_2$  is a parameter wherein  $0 < B_2 < 1.00$ ,

16  $TB_{mad}(n)$  is the average of  $B_{mad}(n)$ , and

17  $B_{mad}(n)$  is defined as

$$18 \quad B_{mad}(n) = \frac{u(n) \max \{T_{ave}(n-1), T_{fi}(n-1)\}}{MAD(n)}$$

19 wherein

20  $u(n)$  is the available channel bandwidth,

21  $T_{ave}(n-1)$  is the average encoding time interval for the  
 22 Inter-frame, and

23  $MAD(n)$  is the mean absolute difference between the  
 24 current frame and the previous frame.

1 5. (Original) The method for rate control according to  
 2 claim 4, wherein the target encoding time interval is further  
 3 adjusted by  
 4

$$T_{fi}(n) = \min \left\{ \frac{5}{4F_r}, \max \left\{ \frac{3}{4F_r}, T_{fi}(n) \right\} \right\}.$$

6. (Original) The method for rate control according to claim 3, wherein the average encoding time interval for the Inter-frame is determined based on an actual encoding time interval for the Inter-frame.

7. (Original) The method for rate control according to claim 6, wherein the average encoding time interval for the Inter-frame is further determined based on the target encoding time interval and the number of skipped frames due to buffer overflow.

8. (Original) The method for rate control according to claim 7, wherein the average encoding time interval for the Inter-frame is determined using the following equation:

$$T_{ave}(n) = (1-x)T_{ave}(n-1) + \chi * \max \left\{ T_c(n), \frac{1}{F_r} - RT_{st}(n-1) \right\}$$

wherein

$\chi$  is a weighting factor,

$T_c(n)$  is the actual encoding time,

$F_r$  is a predefined frame rate, and

$RT_{st}$  is further defined as

$$RT_{st}(n) = 0 \quad \text{if} \quad \max \{ T_c(n), T_{fi}(n) \} < \frac{1}{F_r} - RT_{st}(n-1) \quad \text{or} \quad N_{post}(n) > 0,$$

$$RT_{st}(n) = \{ T_c(n), T_{fi}(n) \} + RT_{st}(n-1) - \frac{[(\max \{ T_c(n), T_{fi}(n) \} + RT_{st}(n-1)) F_r]}{F_r}$$

otherwise,

wherein  $N_{\text{post}}(n)$  is the number of skipped frames due to buffer overflow.

9. (Original) The method for rate control according to claim 5, wherein the target buffer level is determined such that an Inter-frame which is nearer to the I-frame in the GOP has a higher target buffer level compared to another Inter-frame which is further from the I-frame belonging to the same GOP.

10. (Original) The method for rate control according to claim 9, wherein the target buffer level is determined using the following equation:

$$T \arg et(n) = T \arg et(n-1) - \frac{B_c(t_{i,l}) - \delta * B_s}{N_{\text{gop}} - 1} * \sum_{j=0}^{N_{\text{post}}(n-1) + S_c(n-1)} W_{\text{pos}}(n+j)$$

wherein

Target(n) is the target buffer level,

$N_{\text{gop}}$  is the number of frames in a GOP,

$B_s$  is the buffer size,

$B_c$  is the actual buffer occupancy,

$S_c$  is an average number of skipped frames due to insufficient available computational resources for encoding the Inter-frame according to the desired frame rate, and

$W_{\text{pos}}(l)$  is the position weight of the  $l^{\text{th}}$  Inter-frame which satisfies

$$\sum_{l=1}^{N_{\text{gop}}-1} W_{\text{pos}}(l) = N_{\text{gop}} - 1$$

and

$$W_{\text{pos}}(1) \leq W_{\text{pos}}(2) \leq \dots \leq W_{\text{pos}}(N_{\text{gop}} - 1).$$

11. (Original) The method for rate control according to claim 10, wherein the average number of skipped frames due to insufficient available computational resources for encoding the Inter-frame according to the desired frame rate is determined

5 based on an instant number of skipped frames due to the  
 6 insufficient computational resources while encoding the Inter-  
 7 frame.

1 12. (Original) The method for rate control according to  
 2 claim 11, wherein the instant number of skipped frames due to  
 3 insufficient computational resources is determined based on the  
 4 actual encoding time interval and the target encoding time  
 5 interval.

1 13. (Original) The method for rate control according to  
 2 claim 12, wherein the instant number of skipped frames is  
 3 determined using the following equation:

$$4 \quad \tilde{S}_c(n) = \lfloor TST(n) * F_r \rfloor$$

5 wherein  $TST(n)$  is further defined as

$$6 \quad TST(n) = \max \left\{ 0, \tilde{TST}(n-1) + \max \{ T_c(n), T_{\beta}(n) \} - \frac{1}{F_r} \right\}$$

7 and  $\tilde{TST}(n-1)$  is defined as

$$8 \quad \tilde{TST}(n-1) = TST(n-1) - \frac{\lfloor TST(n-1) * F_r \rfloor}{F_r}$$

9 wherein

10  $\tilde{S}_c(n)$  is the instant number of skipped frames due to  
 11 insufficient computational resources,

12  $T_c(n)$  is the actual encoding time interval, and

13  $F_r$  is a predefined frame rate.

1 14. (Original) The method for rate control according to  
 2 claim 13, wherein the average number of skipped frames due to  
 3 insufficient computational resources is determined using the  
 4 following equation:

$$5 \quad S_c(n) = \lfloor (1 - \theta) S_c(n-1) + \theta * \tilde{S}_c(n) \rfloor$$

6 wherein

7  $\theta$  is a weighting factor.

15. (Original) The method for rate control according to claim 14, wherein the target bit rate is determined based on the average encoding time interval for the Inter-frame, the average number of skipped frames due to insufficient computational resources, the target buffer level, the available channel bandwidth and actual buffer occupancy.

16. (currently amended) The method for rate control according to ~~claims 8 and 15~~ claim 8, wherein the target bit rate is determined using the following equation:

$$\tilde{f}(n) = \max \left\{ u(t_{n,i}) * \max \{ T_{ave}(n-1), T_{fi}(n) \} + (\gamma - 1)(B_c(t_{n,i}) - Target(n)) \right\}$$

wherein

$\tilde{f}(n)$  is the target bit rate,

$t_{n,i}$  is the time instant the  $n$ th Inter-frame in the  $i$ th GOP is coded, and

$\gamma$  is a constant.

17. (Original) The method for rate control according to claim 16, wherein the target bit rate is further adjusted by a weighted temporal smoothing using

$$f(n) = \max \left\{ \frac{u(t_{n,i}) * \max \{ T_{ave}(n-1), T_{fi}(n) \}}{3} + H_{hdr}(n-1), \mu * \tilde{f}(n) + (1 - \mu) * f(n-1) \right\}$$

wherein

$f(n)$  is the smoothed target bit rate,

$\mu$  is a weighting control factor constant, and

$H_{hdr}(n)$  is the amount of bits used for shape information, motion vector and header of previous frame.

18. (currently amended) The method for rate control according to claim 1, further comprising ~~the following steps~~:

Determining a sleeping time of each frame after the frame is coded,

5 Determining a starting encoding time of each of the frame  
 6 based on the computed sleeping time,  
 7 Determining a starting decoding time of a next frame based  
 8 on the computed starting encoding time, and

9 Transmittting the determined starting decoding time to a  
 10 decoder which is designed for decoding the video sequences.

1 19. (Original) The method for rate control according to  
 2 claim 18, wherein the sleeping time is determined according to  
 3 the following formula:

$$4 \quad ST_c(n) = \max \left\{ \frac{1}{F_r} - RT_{st}(n-1) - \max \{ T_{fi}(n), T_c(n) \} 0 \right\} + \frac{N_{post}(n)}{F_r}$$

5 wherein  $ST_c(n)$  is the sleeping time of the coding  
 6 process.

1 20. (Original) The method for rate control according to  
 2 claim 19, wherein the starting encoding time is determined  
 3 according to the following formula:

$$4 \quad SCT(n) = T_c(n) + SCT(n-1) + ST_c(n)$$

5 wherein  $SCT(n)$  is the starting encoding time.

6 21. (Original) The method for rate control according to  
 7 claim 20, wherein the starting decoding time is determined  
 8 according to the following formula:

$$9 \quad SDT(n) = \frac{\lfloor SCT(n) * F_r \rfloor}{F_r}$$

10 wherein  $SDT(n)$  is the starting decoding time.

1 22. (Original) An apparatus for controlling the rate for  
 2 encoding a video sequence, wherein the video sequence comprises  
 3 a plurality of Group Of Pictures, wherein each Group of Picture

comprises at least and I-frame and an Inter-frame, the apparatus comprises a processing unit being adapted to perform the following steps for the encoding of each Inter-frame in the Group of Picture:

Determining a desired frame rate based on an available bandwidth of a channel which is used for transmitting the video sequence and on available computational resources for the encoding process;

Determining a target buffer level based on the desired frame rate and the position of the Inter-frame with respect to the I-frame; and

Determining a target bit rate based on the target buffer level and the available channel bandwidth, wherein the target bit rate is used for controlling the rate for encoding the video sequence.

23. (Original) A video encoding device for controlling the rate for encoding a video sequence, wherein the video sequence comprises a plurality of Group Of Pictures, wherein each Group of Picture comprises at least and I-frame and an Inter-frame, the encoding device comprises a processing unit being adapted to perform the following steps for the encoding of each Inter-frame in the Group of Picture:

Determining a desired frame rate based on an available bandwidth of a channel which is used for transmitting the video sequence and on available computational resources for the encoding process;

Determining a target buffer level based on the desired frame rate and the complexity and the position of the Inter-frame with respect to the I-frame; and

Determining a target bit rate based on the target buffer level and the available channel bandwidth, wherein the target bit rate is used for controlling the rate for encoding the video sequence.